



Designing an Automated Composter for Food Waste Management with the Implementation of Internet of Things

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Abstract: Composting food waste is a delicate procedure that requires specific infrastructure and machinery that can gradually transform the wastes to nutrient-rich manure. Nevertheless, it also desires a constant attention by experts to achieve a quality outcome. Therefore, automatic composting machinery is a promising new idea as modern technology is taking over the world with its high efficiency. The objective of this paper is to build a fully automated composting machine that can help to reduce food waste using a more efficient and environmentally friendly method. This machine has its special features of heating, cooling and grinding which is simple and easy to use for every consumer at just one touch of a button. In addition, it uses a special filter to eliminate unpleasant odor to ensure consumer's space of mind. The composting process uses node microcontroller (MCU) to run its operation and Internet of Things (IoT) with a developed mobile application to measure the amount of food waste, current process and its moisture content before turning the waste into high nutrient flakes at around 10% of its original volume. It will also notify the consumer when the whole process is done and the final product is ready to use. The produced flakes are good for nurturing soils, use as fertilizer, and renewable source of energy or animal feed. The benefit is to help reduce handling cost of waste at landfill. Excessive logistical energy is required to send food waste to landfill if conventional equipment is applied. This product has a high potential to penetrate the end users who usually cook at home and also the industrial food manufacturers whether from medium to large which produces a lot of raw waste. Essentially, this machine allows food waste, through implementation of IoT to be converted to usable fertilizer.

Keywords: Food waste, automated composting machine, MCU microcontroller, Internet of Things

1. Introduction

A research by Solid Waste Corporation (SWCorp) Malaysia concluded that annually an average Malaysian household throws away more than one month's salary worth of unconsumed food [1]. The food that Malaysians tend to waste not only affected their incomes but also the wasted cost is estimated to be enough to feed millions of other unfortunates daily. SWCorp also stated that quarter of the food is mainly wasted by Malaysians during stages of food preparation, food production and also food consumption [1]. Another study conducted by the corporation shows that Malaysians generated 38,000 tons of solid waste daily of which 15,000 tons of them were food waste and it was proven that 20%, which is approximately around 3,000 tons of those food waste were avoidable [1].

The problem with food waste among Malaysians is due to the lack of awareness of why reducing food waste is crucial. This problem has not been taken seriously even by people with higher power such as the government because here in Malaysia, we are fortunate to have low percentage of poverty and starved communities compared to those countries with bigger population such as India, Bangladesh, Philippine and others [2]. Excessive food waste is dangerous to the environment as they release methane gas that causes global warming and climate change [3]. Other than global warming, there are also other problems that worry the authorities such as the increase in managing costs. A study found that as the number of food waste increases, the amount of time and money need to be increased as well and at the same time, bigger space is needed in order to handle the food waste [4].

Due to these problems, actions should be taken seriously in order to decrease the effect of food waste to the environment. In Malaysia, the government has introduced a waste segregation law to help manage food waste [3] while collaborating with non-government bodies to roll out a MYSaveFood campaign to educate and encourage Malaysians on food wastage. The campaign is also intended to carry out research from the food production stage right up to when it goes to the end-users in order to identify the real issues behind food wastage. Other woke organizations have also helped in creating other alternatives to help reducing the percentage of food waste in Malaysia. Grub Cycle, which is a local social enterprise is doing its part to reduce food waste by introducing another approach which is by collecting dry foodstuffs that are nearing their expiry date and sells them at low prices to needy groups.

The most common method to discard food waste is by composting them into organic fertilizer. However, composting processes are usually time consuming and require a lot of efforts. It requires deep knowledge and constant attention by experts to achieve a quality outcome in a timely fashion. Technology is evolving every day and cloud computing, along with the growth of Internet of Things (IoT) systems, frameworks and architectures, has recently played a significant role in the development of intuitive and unsupervised systems and services [5]. In 2018, a study introduced a service that combined an innovative IoT composting appliance and a cloud service that can perform all necessary actions to provide a completely unsupervised and uninterrupted composting procedure [6].

The rise of smart-devices has inspired several researchers to address the ability of composting appliance to compose efficiently, unsupervised and uninterrupted. One of the researches talked about an evaluation system that is able to assess the compost's maturity and its progress by implementing O₂ and CO sensors to the system [7]. Other research presented a system that measures the gas emissions of the compost material to decide the intake of oxygen in the compound, thus guaranteeing a sustained and efficient composting procedure [8]. A more interesting approach was introduced by Rahane et al. where a composting infrastructure that not only periodically performs specific tasks (stirring, ventilating, etc), but also performs dynamically invoked measures, according to the compost material's temperature [9].

In this paper, an approach where IoT and Automated System based machine is built to help converting the food waste into organic fertilizer that enable users to use it right after the whole processes are completed in less than 24 hours. Compared to the original ways of composting food waste into organic fertilizer, this integrated IoT based machine is much more efficient and capable of reducing the managing cost that has been the concern as the number of food waste in Malaysia increases. The machine consists of three processes that include a heating process, cooling process and grinding process. The implementation of IoT in the system enables users to manage and monitor the processes with a touch of a button.

2. Materials and Methods

Node MCU is a microcontroller that has the feature to connect to Wi-Fi on itself. It will communicate with a smartphone app which shares the same access point of Wi-Fi. For this project, it will connect to the app called "Blynk" and users are able to control and monitor the system through this app. An overall process flow is illustrated in a form of block diagram as shown in Fig. 1 and the whole process can be visualized through the system's schematic diagram shown in Fig. 2.

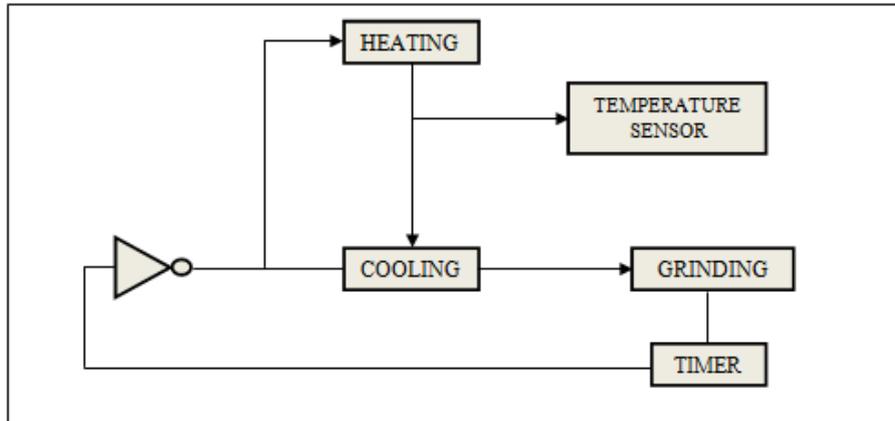


Fig. 1 - Block diagram

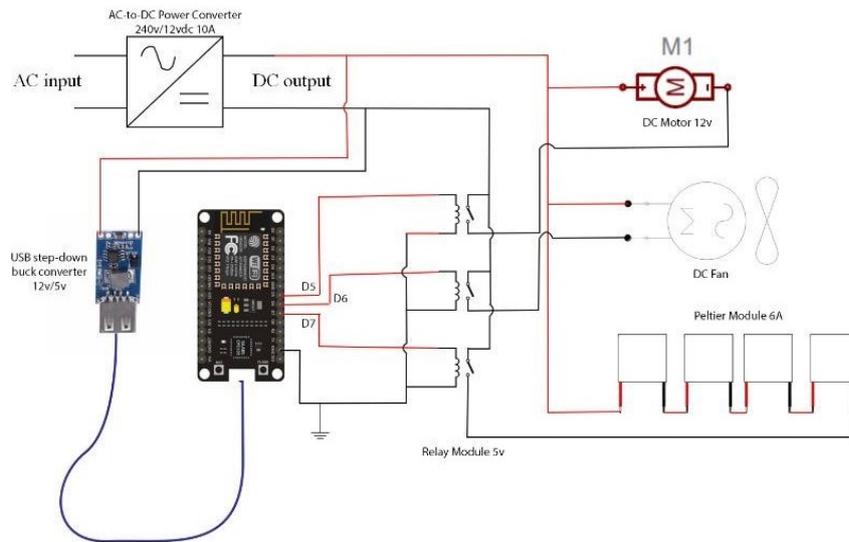


Fig. 2 - Schematic diagram of the system

Based on Fig. 2, all of the devices in this circuit are operated in dc. The power of the Node MCU is supplied by the USB step down converter 12V/5V through micro USB connector. The pins D1 and D2 is used for input for load sensor module HX711 and the pins D7, D6 and D5 are connected to the relays which act as the switch for drying, cooling and grinding process circuit respectively. After a user selects the operation mode (according to weight and volume of the food waste) and enter the “confirm” button, the system will start the heating process. During this mode, the output pin will become high and turn on the relay correspond to it and thus activate the heating circuit. The heating parts of the Peltier module (which is in contact with the surface of the bowl) will start to become hot as the current is flowing. It will heat up to 50°C. The heat will heat up the bowl and vaporize the water inside the waste for a smooth grinding.

After the heating, the microcontroller will automatically turn OFF the pin D7 and activate the pin D6 which represents the cooling process. The fan will start to rotate. The fan will absorb the heat and also the air through the carbon filter. The carbon filter will filter the smell from the waste and thus resulting in an odorless end product. After the cooling process is completed, the pin D7 will become HIGH and turn the relay which connects the dc motor to rotate the grinder. The grinder will grind the residue into fine powdered fertilizer. The product should be dried, odorless and therefore a fine fertilizer is produced which is ready to sow on ground. The load sensor which connects to pin D1 and D2 of the microcontroller will continuously record the weight of the bowl. The weight is shown in the display of the app.

3. Results and Discussion

Fig. 3 shows the final result of this project. Here, plywood is used for the outer container because of its characteristics which are heat resistant and durable that make it suitable for this project. The inner container where the food waste is deposited uses a metal bowl for a better heat distribution in order to dry the food waste.

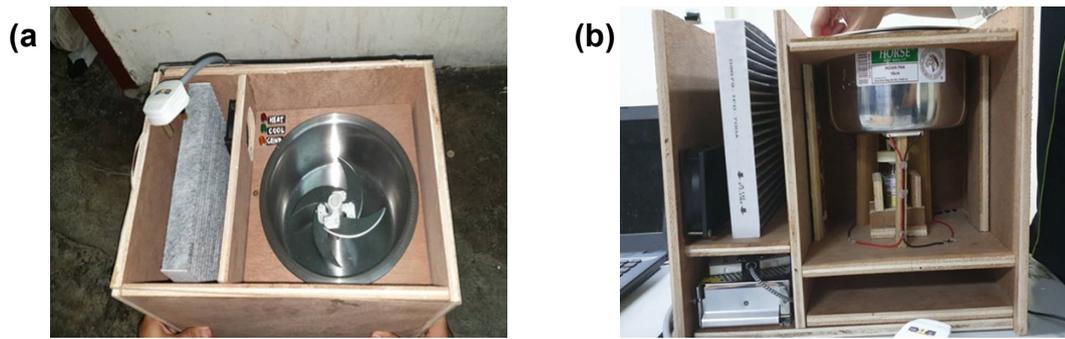


Fig 3. SEQ Figure * ARABIC 3 - (a) prototype design upper view; (b) side view

The product will start off with the heating process to remove excess moisture from the food waste. The heating process takes about 60 minutes depending on the volume of the food waste. The heating plate used in this project can reach up to 60°C. If the container is full then the heating process will take longer time. After heating, the contents are cooled. During this process, fans will automatically turn on and filters the air inside the container through the carbon filter. This reduces odor from the food waste and decrease the temperature inside the container to room temperature at 27°C.

Last but not least, the machine will grind all the food waste inside the container until it breaks into smaller pieces. Grinding takes longer time compared to other process to ensure the food waste is evenly crushed so that consumer can use it as fertilizer. With the implementation of IoT, users are able to know what are the current process and the weight of the food waste before the process start and after it is completed. Users also will be notifying by the application on mobile phone once the fertilizer is ready to be used. Fig. 4 shows the current processes which are heating, cooling, grinding displayed by the application on mobile phone and weight displayed on mobile application detected by the load sensor.

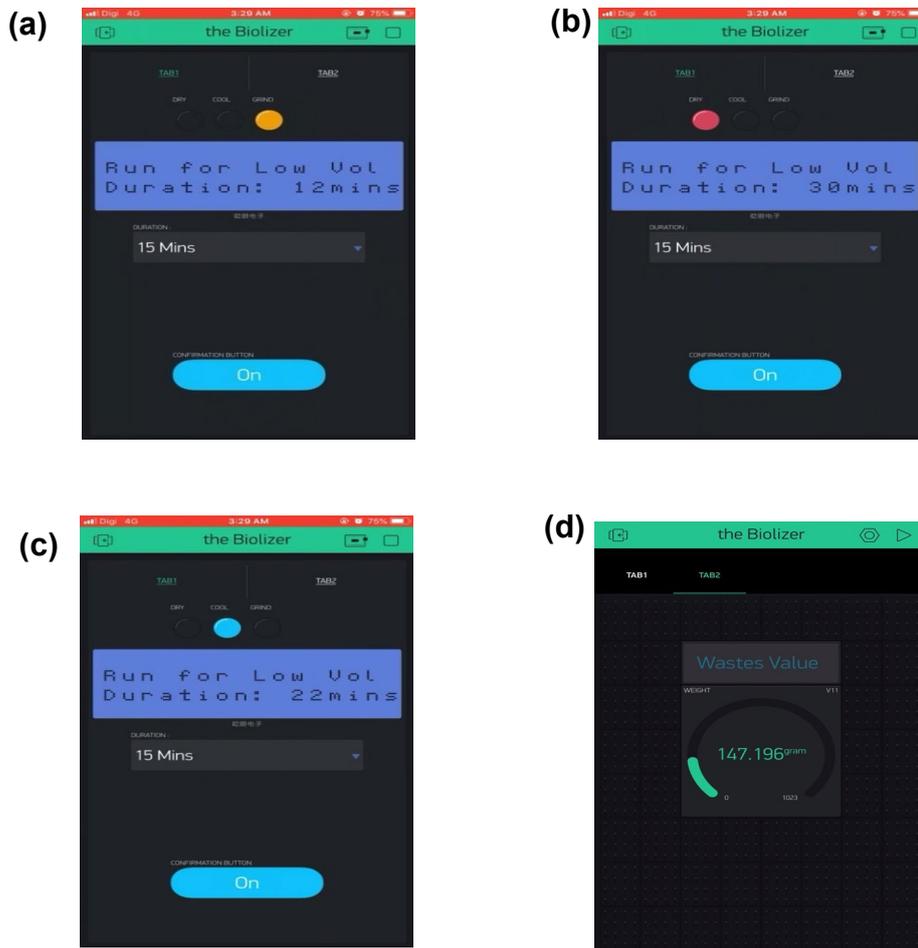


Fig. SEQ Figure * ARABIC 4 - blynk app interface (a) cooling process; (b) heating process; (c) grinding process; (d) weight display

After completing this project, there are several improvements that can be made to this product. Because of the limitation on budget, the product made was having a lot of lacking in performance that can be improved in the future for better results. The first improvement is by increasing the types of sensor in the system. For this product there was only one type of sensor used which is a load sensor in order to track the weight of the food waste in the container. As for the improvement, adding more sensors such as temperature sensor, humidity sensor, and ultrasonic sensor will improve the efficiency of this product.

First thing first, the ultrasonic sensor is the most important addition. Its function is to measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back [10]. For this project, it can be used so that users will know how full the capacity of food waste inside the container is. Instead of getting to know by our own, the sensor will sense it and send the data to the application so that it is easier to predict how long the whole process is going to be, depending also on the volume.

Next is the humidity sensor. At first, the product will predict, measure and report both moisture and air temperature. The ratio of moisture in the air to the highest amount of moisture at a particular air temperature is called relative humidity [11]. With respect to this product, there is no humidity sensor is used. So here, adding this sensor would help in detecting the humidity level on the food waste since food waste consists of many types of wet food and this will affect the duration of the heating process. If the food waste is dry, then the product can reduce the heating process time while reducing the power consumption.

Apart from that, adding temperature sensor would also be necessary to increase the efficiency of the product since its presence can help in consuming less electrical energy. The temperature sensor includes thermocouples and thermistors that touch the object they are to be measured, and non-contact sensors that measure the thermal radiation a heat source releases to determine its temperature [12]. Basically, the temperature sensor and humidity sensor are relatable since humidity sensor need to detect first the level of humidity of food waste in the container prior to temperature sensor detects how high would be the maximum temperature needed to dry the food waste. Further, the humidity sensor will measure whether the food waste is already dried or not at a certain temperature. As such, the product does not need to set to a high temperature to dry the food waste. If in case the food waste is completely dried even at temperature as low as 30°C, the heating process can stop and this would help reduce the power consumption [13].

Literally, those are the improvements that can be made to this project. Focusing more on how it operates can increase the performance of the product. Instead of simply being a smart waste product, it can also get the label for smart energy product. Turning months of decomposing food waste machine into less than 24 hours while making it available for each household would be the greatest contribution to the changes of environment it this world [14].

4. Conclusion

As a conclusion to this capstone project, an automated food waste recycler has been successfully built using microcontroller to control the process of composting food waste. The overall process of heating, cooling and grinding was able to be executed sequentially according to the time set using the microcontroller. In addition, every process was conducted using a DC power supply of only 3v and 5A which is only a small amount of energy to power up the machine. For the hardware, it was also able to withstand the heat and vibration motion during fast grinding without any parts collapsing. The final result of reducing the total food waste weight of up to 90% however did not meet its specifications as the food weight can only be reduced up to 70%. In the future, the expectation may include for the product to have its design up to commercial standard which accounts for the outer case of the product to be molded with plastic injection and the product has a better grinding solution so that it will be a necessity for every household in helping the world reduces food waste.

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